A rheological model for the compaction of fibrous agricultural materials ☆

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Abstract

A five element non-linear rheological model was developed for analysing the compression and relaxation behaviour of fibrous agricultural materials. The model's mechanical elements have non-linear characteristics (unlike existing models), and feature a creep curve that approximates more closely to the real behaviour of fibrous materials. The model's response to an applied compressive load has three stages, namely, inertial up to the initial density, elastic up to the elastoplastic point, and thereafter elastoplastic.

Mathematical analysis of the model involves non-linear differential equations developed from the compression and creep response of the material, thus making the model parameters more closely related to the physico-mechanical properties of the compacted material. Such properties, found to be dominant in the post-compression recovery and permanent deformation phases of the material, include the elastic resistance, the plastic modulus and the internal friction of the wafer formed.

Application of the model to extrusion compaction indicates the significant effect which thermoplastic strains have on the creep response of a fibrous material. Analysis of experimental results with the model indicate an optimum hold time of 2·5 and 5s for ground and unchopped barley straw samples, respectively, and higher values of residual elastoplastic resistance for the unchopped samples; residual permanent deformation was estimated to constitute 54–77% of total material deformation.

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